Children’s Health and Unconventional Natural Gas Development

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June 3, 2020
Collaborative on Health and the Environment Webinar
Outline

- Background
  - Unconventional natural gas development (UNGD)
  - Air and water pollutants
  - Health effects
- UNGD and Children’s Health
  - Proximity metrics
  - Adverse birth outcomes
  - Childhood cancer
- Recommendations for Future Work
Background
Processes Involved in Unconventional Oil & Gas Development

- Horizontal drilling
- Hydraulic fracturing (fracking)
  - Involves pumping large amounts of water, mixed with sand and other chemicals, under high pressure to fracture shale around the well

Source: www.epa.gov
Shale Plays at Home and Around the World
Examples of Pollutants

- **Water pollutants**
  - Flowback water storage, treatment, and disposal perhaps “riskiest”
  - Brings back with it hydrocarbon products, chemical additives required to fracture shale, naturally-occurring contaminants from shale itself
  - Metals (Ba, Mg, Sr), salts, radioactive isotopes
  - Endocrine disruptors

- **Air pollutants**
  - From diesel-powered drill rigs, hydraulic fracturing pumps, trucks transporting materials to and from drilling sites, completion venting
  - NOx, particulate matter (PM$_{2.5}$), VOCs
Human Health Impacts

Noise, odors, and stress
Birth outcomes (birth weight, preterm birth, birth defects)
Nasal and sinus symptoms
Asthma exacerbations
Migraines
UNGD and Children’s Health
Where Does the Research Stand?

- Research out of Colorado, Pennsylvania, Texas
- Much of the work on UNGD and health effects still uses proximity metrics as a surrogate for exposure
  - Useful when a public health problem is new, exposure data may be lacking
  - Analysis via geographic information systems (GIS) software (e.g., inverse distance weighting)
- Disadvantages:
  - Hypothesis-generating
  - May not account for geological, meteorological, or other factors affecting the movement of pollutants through water, soil, or air

Stacy 2017, Current Epidemiology Reports
Proximity Metrics

- Inverse distance weighted (IDW) well count commonly calculated for each mother living within 10-miles of UNGD (McKenzie et al. 2014)

\[ IDW \text{ well count} = \sum_{i=1}^{n} \frac{1}{d_i} \]

- **IDW well count**: inverse distance weighted count of active, unconventional natural gas wells within a 10-mile radius of maternal residence in the birth year

- \( n \): the number of existing unconventional wells

- \( d_i \): the distance of the \( i \)th individual well from the mother’s residence
**Proximity Metrics (continued)**

\[ IDW \text{ well count} = \sum_{i=1}^{n} \frac{1}{d_i} \]

**Example:**

If \( d_1 = 8 \), \( d_2 = \frac{1}{2} \), \( d_3 = 9 \), and \( d_4 = 4 \):

\[ IDW \text{ well count} = \frac{1}{8} + 2 \cdot \frac{1}{9} + \frac{1}{4} \]

\[ IDW \text{ well count} \approx 2.5 \]
Figure 1. Adjusted odds ratios (OR) and 95% confidence intervals (CI) from studies examining birth outcomes and proximity to UNGD. ORs reported for the most vs. least exposed from each study.
Cancer in children is relatively rare but remains the leading cause of death by disease past infancy among children in the United States. Little is known about the causes.

Incidence among U.S. children <15 years of age: 16 per 100,000
Childhood Cancer in Pennsylvania

In the news... increasing community concerns regarding environmental contributions, including UNGD, to childhood cancers in southwestern PA, particularly Ewing’s sarcoma.
Childhood Leukemia

- Leukemia is a cancer that occurs when the bone marrow produces abnormal white blood cells. It is often described as being either acute or chronic.

- Almost all childhood leukemia is acute.
  - Acute lymphocytic leukemia (ALL)
  - Acute myelogenous leukemia (AML)

- Risk factors include:
  - Intrinsic (error in stem cell replications)
  - Extrinsic (environmental factors, i.e. benzene exposure)
  - Genetic (chromosomal mismatch)
  - Unknown
Several studies have noted potential carcinogenic exposures related to UNGD activities. A review by Elliott et al. (2017) identified 20 leukemogenic water and air pollutants associated with UNGD. Twenty unique compounds had evidence of ↑ risk for leukemia and/or lymphoma, including:
- Benzene
- 1,3-butadiene
- Cadmium
- Diesel exhaust
- Several polycyclic aromatic hydrocarbons (PAHs)
UNGD and Childhood Cancer

A human health risk assessment (McKenzie 2012) of air emissions in Garfield County, CO found that residents living ≤0.5-mile of UNGD had greater cumulative cancer risks compared to those living >0.5-mile.

- Driven mostly by benzene exposure

Fryzek et al. (2013) compared incidences of the two most common childhood cancers, leukemia and central nervous system (CNS) tumors, in PA counties before and after drilling.

- Observed numbers of cancer cases, however, were close to expected both before and after.

- Lag period between drilling activities and clinically observable cancer too short?

In McKenzie et al. (2017), 5 to 24-year-olds diagnosed with ALL were 4.3 (95% CI: 1.1-16) times as likely as controls to live in close proximity to UNGD (i.e., in their highest exposure group)

- No association between UNGD and ALL among 0 to 4-year-olds, nor for non-Hodgkin lymphoma.
Figure 3. Counts of Total Childhood Cancer Cases and Locations of Unconventional Gas Wells

Legend
- Active Wells Spudded 2006-2015

Childhood Cancer Cases
- Count
  - 1 - 3
  - 4 - 7
  - 8 - 14
  - 15 - 33
  - 34 - 171
We obtained birth records, and childhood cancer records linked to their birth records, through an IRB-approved application process with the Pennsylvania Department of Health.

Using this virtual cohort to investigate a number of pre- and postnatal risk factors for childhood cancers (Stacy et al., Am J Epidemiol, 2019).

Infants born from 2007-2015, when UNGD was expanding in PA.

Similar to our (Stacy et al. 2015) and others’ previous work, we calculate an inverse distance weighted (IDW) well count accumulated for all active, unconventional natural gas wells drilled within 10-miles of the mother’s residence.

Examining different periods of exposure: prenatal versus postnatal.

Pregnancy and early childhood are sensitive time periods of development, including for environmental onslaughts that may affect health later in life.
Recommendations for Future Work
A growing body of literature suggests that communities living close to UNGD may be at greater risk for certain health outcomes, particularly infants and children.

There is evidence that proximity to these activities is associated with increased risk for several birth defects, preterm birth, and reduced fetal growth. However, results differ somewhat by region and study population.

Epidemiologic studies using UNGD proximity/density metrics are primarily hypothesis generating.

What specific agent(s) might be responsible for the associations we’re seeing?
Where Do We Go From Here?

- Future studies would greatly benefit from using more granular estimates of exposure or conducting more individualized exposure assessments.
  - Portable sampling equipment
  - Measurement of biomarkers of exposure in biospecimens collected from study participants (e.g., measuring PAH- or benzene-DNA adducts in blood)
- GIS methods may also aid in estimating personal exposure to UNGD
  - e.g., use of global positioning system technology to integrate study population activity data with measured concentrations of environmental contaminants
Acknowledgments and Conflicts of Interest

- My mentor, Dr. Jian-Min Yuan
- Our collaborators at the University of Pittsburgh
- I have no conflicts of interest to disclose.
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